NACA

RESEARCH MEMORANDUM

EFFECT OF CHORDWISE VANES ON AMPLITUDE OF TAIL BUFFETING

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SUMMARY

Flight tests have been made with a P-51D airplane to determine the effect of chordwise vanes on the amplitude of tail buffeting. The tests made during abrupt pull-ups to the buffeting boundary included strain measurements on wing and tail and tuft studies over the wing. The tests covered a Mach number range of from 0.40 to 0.75 at a pressure altitude of 30,000 feet and were made with and without vanes.

The results indicate that the vanes tested have no appreciable effect on the amplitude of tail buffeting.

INTRODUCTION

Tests made on the XP-51 airplane (reference 1) had shown that the flow direction over the outer portions of the wing at higher speeds was toward the fuselage. Since the flow over the inner portion was away from the fuselage, it was thought that the junction of the two flows which occurred within the span of the horizontal tail would affect the buffeting loads. Chordwise vanes were accordingly designed to separate and realine these flows and were tested in flight on a North American P-51D airplane. The wing plan forms and sections for the XP-51 and P-51D are similar.

This report presents the results of the tests made with chordwise vanes and compares them with similar flight tests made without such vanes. Comparisons are made for Mach numbers up to 0.75 of bending moments of the left horizontal stabilizer and shears of both left and right horizontal stabilizers.

APPARATUS AND TESTS

Apparatus

The tests were made with a North American P-51D airplane. With the exception of a vertical-tail extension equivalent to 2.15 square feet of area, the airplane was of standard configuration. Various components of the airplane structure had previously been reinforced to withstand high loads. The pertinent dimensions of the airplane are presented on the three-view drawing of the airplane given in figure 1.

The chordwise vanes used in these tests were installed on the upper surface of the wings as shown in figure 2. The vanes were mounted symmetrically at semispan stations referred to the root chord of about 19, 32, and 48 percent. (See fig. 2(a).) The vanes were triangular in section and tapered in height from 2 inches at about 50 percent of the section chord to about 10 inches at the wing trailing edge. (See fig. 2(b).) The vanes were made of balsa and fastened to the wing with a sandwich of felt and adhesive.

Woolen tufts were distributed over the portion of the left wing inboard of 50 percent of the semispan and aft of about the 40-percent wing chord. Details of this installation are presented in figure 2. During the tests, a gun camera mounted within the engine cowling recorded the action of the tufts.

Measurements of airspeed, altitude, and normal acceleration were made during the tests with standard NACA photographically recording instruments. Strain measurements of wing and horizontal-tail shears and bending moments were recorded by a Miller oscillograph.

Tests

Measurements were made in flight for Mach numbers M up to about 0.75 and accelerations up to about 6g units during abrupt pull-ups to the buffeting boundary as reported in reference 2. The tests were made at a pressure altitude of about 30,000 feet and for a center-of-gravity position of 25.1 percent of the mean aerodynamic chord.

RESULTS AND DISCUSSION

The results of the tests made of chordwise vanes are presented in figures 3 and 4. Sample strain-time records with and without vanes are given in figure 3. The abscissa is the time and half-second intervals have been defined on each record. The deflections of the various traces in the vertical direction refer to the strains in various structural components. The vertical magnification of corresponding strain records agrees to within about 5 percent from flight to flight. These strains are proportional to the loads to which the structure is subjected. The traces giving the bending strain in the two spars of the horizontal stabilizer near the root are identified. The buffeting component of the load on the stabilizer is a vibratory load superimposed on the maneuvering or quasi-static stabilizer load. Hence the double amplitude of the buffeting component is represented on the records by the full height of fluctuation as indicated on the strain record for flight 21 in figure 3. The data of figure 3 are representative of those used in the preparation of figure 4 which compares shear and bending-moment measurements on the horizontal stabilizer with and without vanes. The results of figure 4 are presented in coefficient form as a function of Mach number. The coefficient of shear for either left or right horizontal stabilizer is comparable to a lift coefficient in form and is defined as follows:

$$\text{Shear coefficient} = C_{S_S} = \frac{S_S}{q \frac{S_t}{2}}$$

where

S_S half double amplitude of either left- or right-stabilizer shear due to buffeting, pounds

q dynamic pressure, pounds per foot^2

S_t area of horizontal tail, sq ft (28.0)

The coefficient form for the bending moment measured on the horizontal stabilizer is:

$$\text{Bending-moment coefficient} = C_{BM_b} = \frac{BM_b}{q_t \frac{S_t}{2} \frac{b_t}{2}}$$

where

BM_b half double amplitude of bending moment due to buffeting, inch-pounds

b_t span of horizontal tail, inches

For evaluating the bending-moment coefficient, data for only the left side were available. In both cases the coefficients have been divided by the airplane normal-force coefficient

$$C_{N_A} = \frac{nW}{qS}$$

where

n airplane normal acceleration, g

W airplane weight, pounds

S wing area, feet^2

The ratio C_{S_S}/C_{N_A} gives an approximate measure of the impact load of buffeting in terms of the effective wing loading. The coefficient C_{B_M} is simply the coefficient C_{S_S} times the distance in percent of span between the center of pressure of the buffeting tail load and the strain-gage station.

The scatter of the data of figure 4 is attributed in large part to the unsteady wing flow from which the buffeting loads arise. Although chordwise vanes have proved effective for other purposes (for example, increasing the effectiveness of split flaps on strongly swept wings, reference 3), the results of both shear and bending-moment measurements are an indication that the vanes (solid points) have no effect on the amplitude of tail buffeting.

The results of the strain-gage measurements are verified qualitatively by a comparison of tuft studies made with and without the vanes in place. This comparison is not presented.

CONCLUDING REMARK

The vanes tested were of no apparent benefit in alleviating the amplitude of buffeting at the tail.

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REFERENCES

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2. Mayer, John P.: Effect of Mach Number on the Maximum Lift and Buffeting Boundary Determined in Flight on a North American P-51D Airplane. NACA RM No. L6I10, 1946.

3. Luetgebrune, H.: Beiträge zur Pfeilflügeluntersuchung. Forschungsbericht Nr. 1458, Deutsche Luftfahrtforschung (Hannover), 1941.

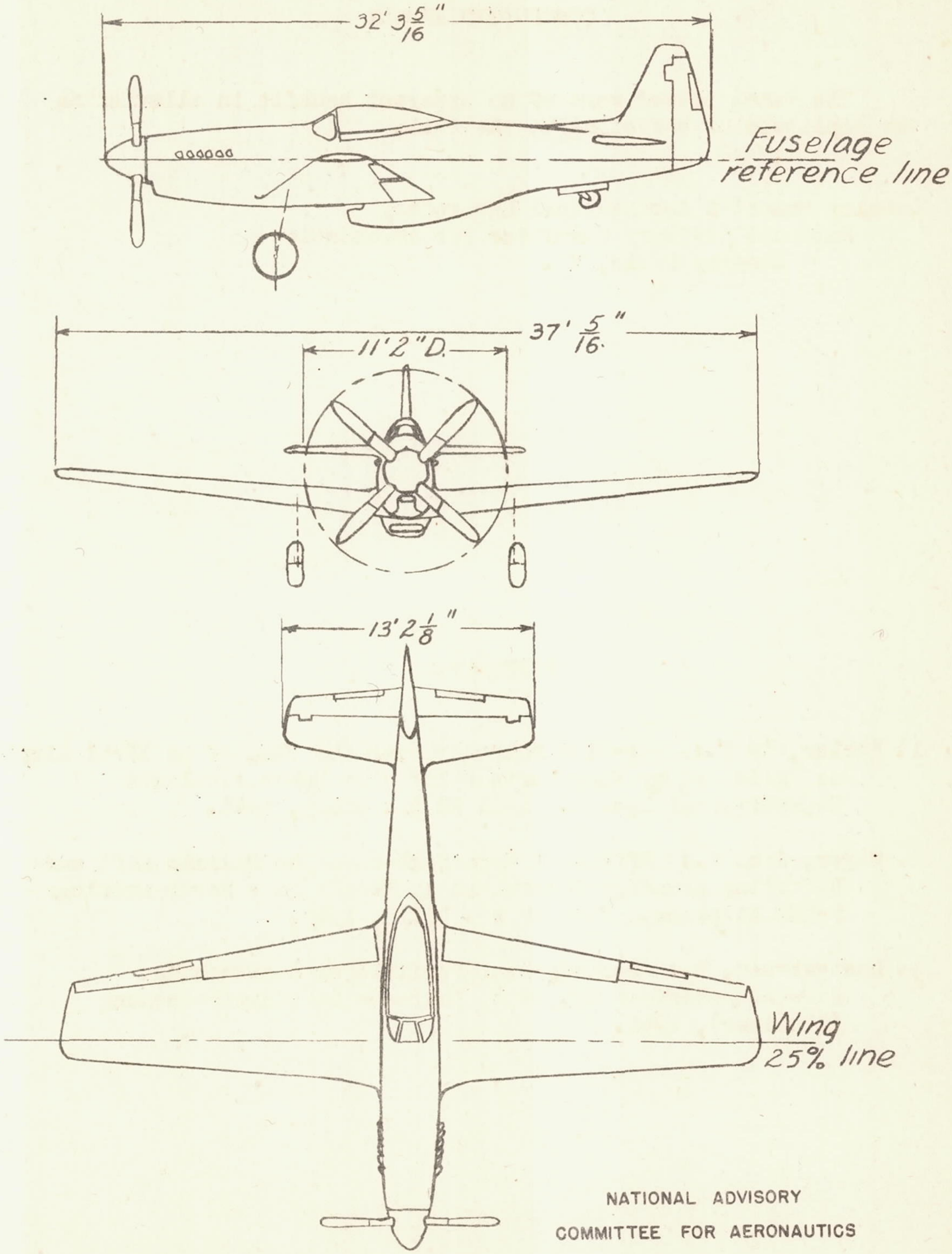
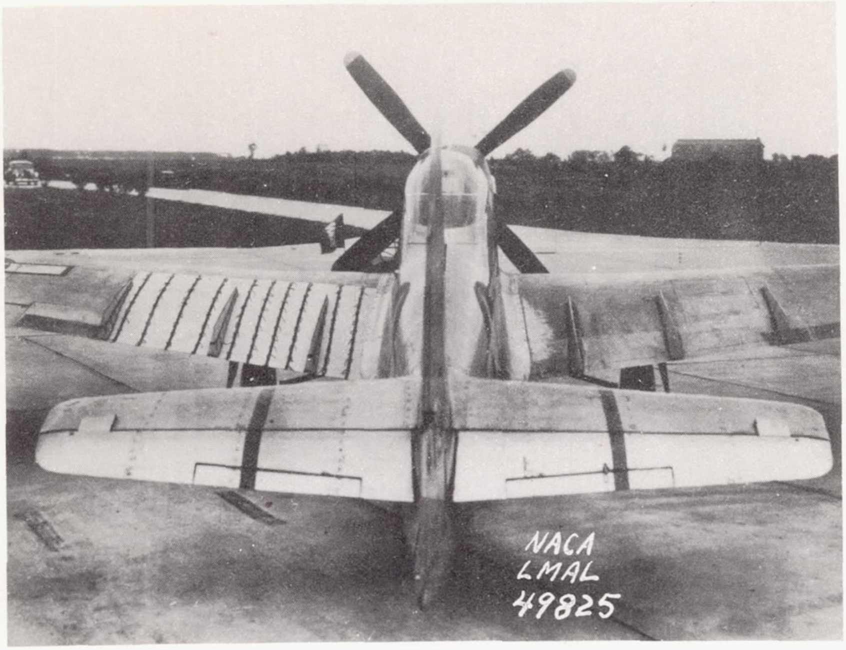
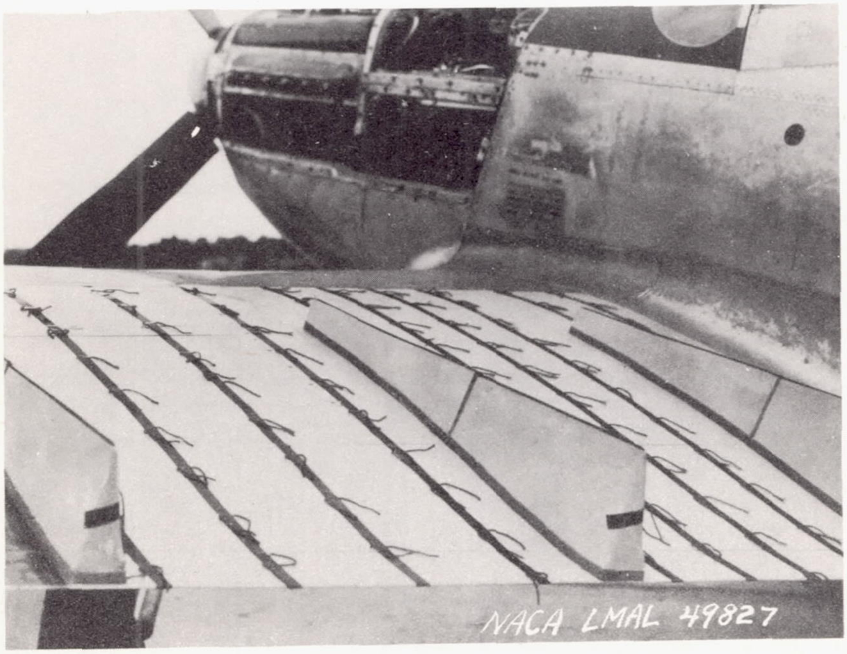


Figure 1.– Three-view diagram of the North American P-51D airplane.

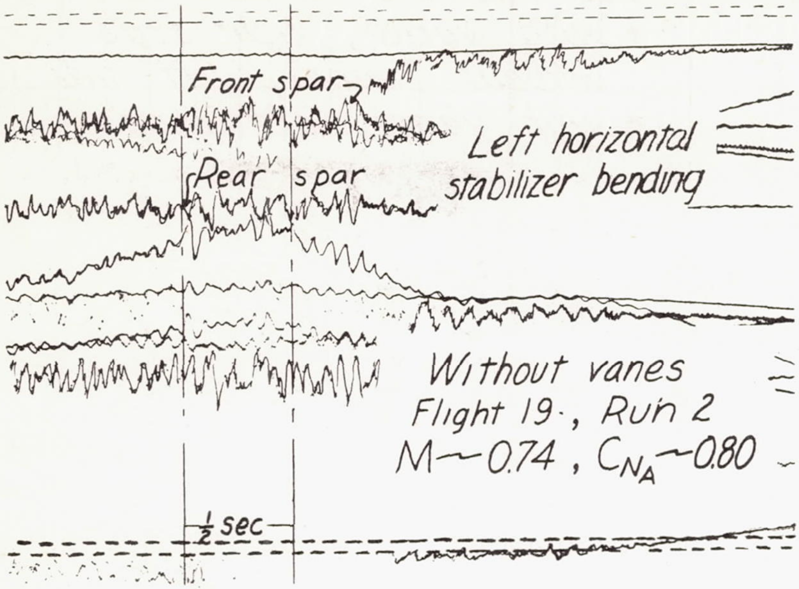


(a) General view.



(b) Detail view.

Figure 2.- Installation of chordwise vanes on North American P-51D airplane.



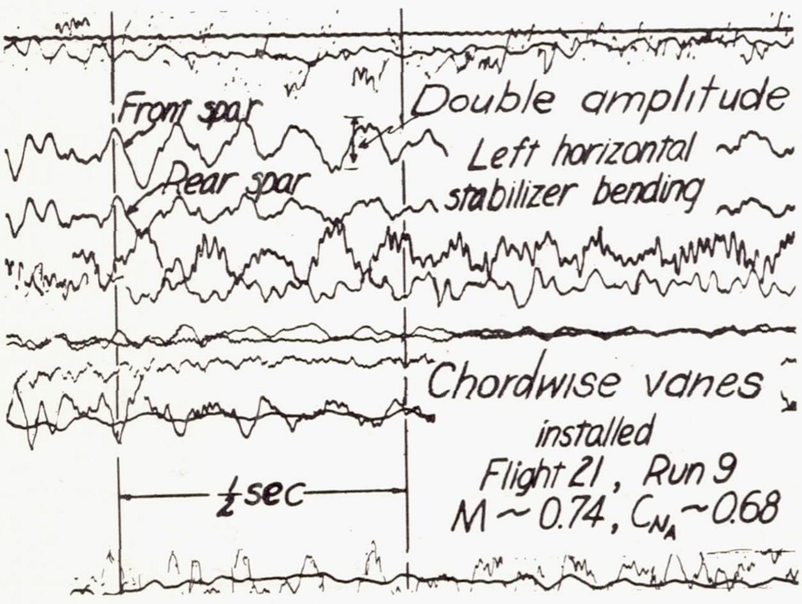


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Figure 3.- Sample strain-time records with and without vanes.

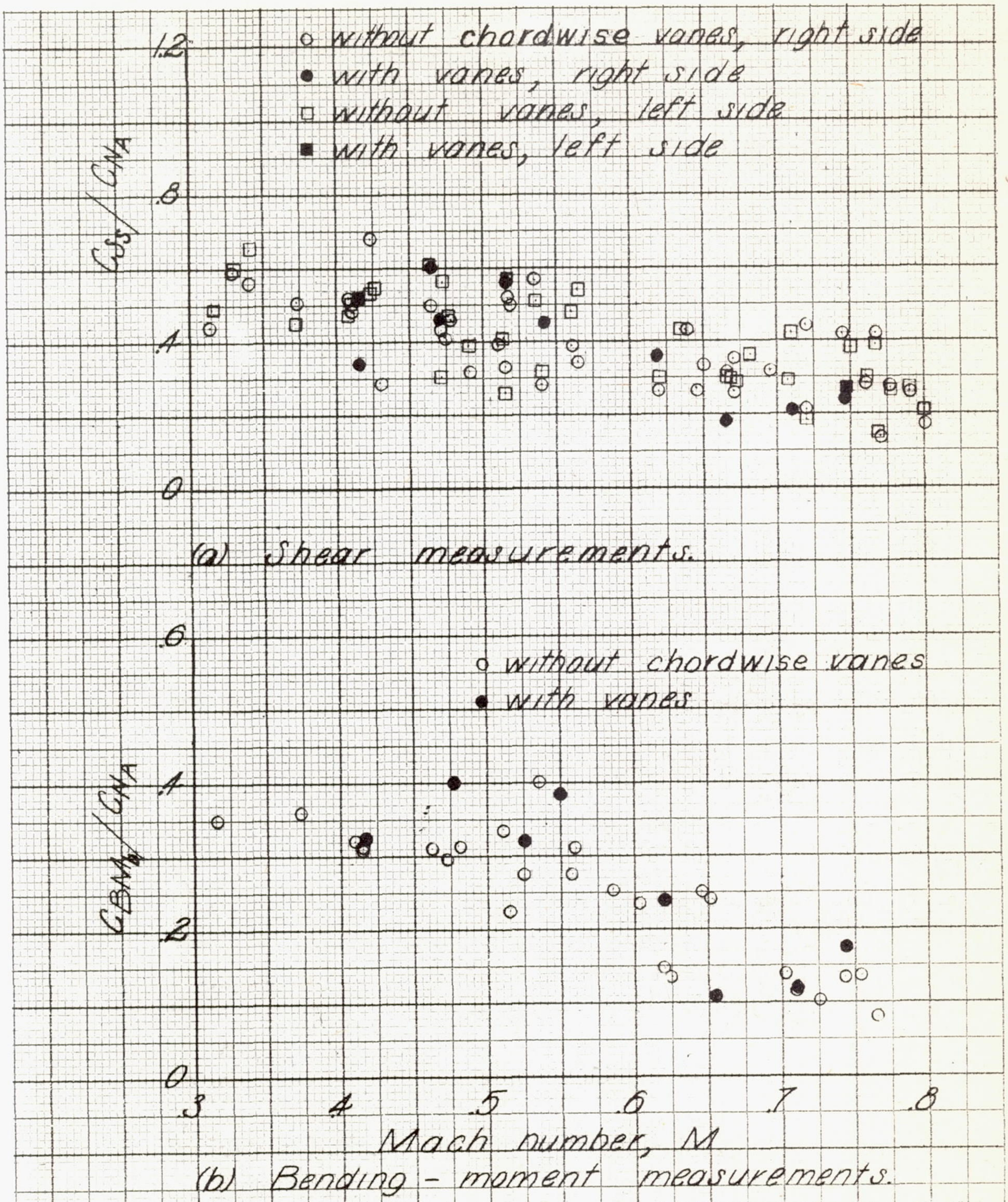

Figure 4. - Effect of chordwise vanes on the amplitude of buffeting.